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(54) **Method of drilling and lining a borehole.**

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EP-A- 0 229 425
EP-A- 0 305 834
EP-A- 0 346 961
US-A- 4 519 452
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Description

The invention relates to a method of drilling and lining a borehole.

In the art of drilling wells in subsurface earth formations it is known to stabilize at the end of a drilling run the borehole wall by a cement lining.

Applicant's co-pending British patent application No. 8814004 discloses a borehole stabilization technique wherein at the end of a drilling run a stinger is lowered into the borehole whereupon slugs of a cement slurry and drilling fluid are subsequently injected into the stinger until the cement slurry fills the annular space around the stinger and the drilling fluid fills the interior of the stinger. Subsequently the stinger is retrieved from the borehole while leaving an annular body of cement slurry and a core of drilling fluid in the borehole whereupon the cement is allowed to set to form an annular lining alongside the borehole wall.

Applicant has now discovered that it is possible to inject a cement slurry into the borehole already during the drilling process so that it is possible to cover the borehole wall already at an early stage with a cement slurry which is directly placed in intimate contact with the surrounding formation in the absence of the deposition during drilling of a mud cake that has to be washed away before placement of the cement lining.

The method according to the invention thereto comprises the steps of drilling a borehole section while circulating a first liquid forming a drilling fluid down through a bore of a multibore drill pipe string carrying a drill bit and up through another bore of said drill pipe string while keeping a volume of a second liquid substantially stationary in an annulus between the outer circumference of the drill pipe string and the borehole wall, characterized in that said second liquid forms an over-retarded cement slurry and that the method comprises the further steps of inserting a third liquid having substantially the same density as the cement slurry into at least a lower portion of said bore and said another bore, and retrieving the bit and drill pipe string from the borehole while the third liquid flows from said bore and said another bore into the wellbore, whereafter the second liquid solidifies to an annular body of solid cement.

Preferred procedures for placing the cement slurry in the pipe-formation annulus can be derived from U.S. patent specification No. 4,718,503. This prior art reference discloses the use of two different fluids in a drilling process, wherein during drilling a first fluid is circulated through the bores of a multibore drill string whereas a second fluid is placed in the pipe formation annulus either by injecting during the drilling process this fluid at the top of the annulus or by interrupting the drilling process and circulating a slug of said second fluid down via at least one of the bores of the drill string and up through the annulus. EP-A-305 834 discloses a method of creating a borehole by inserting an over-retarded cement slurry into an annular space formed between the borehole wall and a sleeve positioned in the borehole. In the method according to the invention the second fluid comprises the over-retarded cement slurry whereas the first fluid comprises the drilling fluid.

Preferably the injected cement slurry comprises an over-retarded hydraulic cement which only hardens out under the influence of a cement solidifying agent. This may be accomplished by using a cement slurry comprising a hydraulic cement which is over-retarded with a glucose compound and by using a cement solidifying agent comprising calcium chloride ($CaCl_2$) to neutralize the retarder. Alternatively the cement slurry may comprise a hydraulic cement which is over-retarded with a retarder that disintegrates at a critical temperature whilst the cement solidifying agent comprises chemicals which cause an exothermic reaction to raise the temperature above said critical value.

The invention will be described in more detail with reference to the accompanying drawing, in which:

- Figure 1 shows a section of a borehole from which a bit and multibore drill string are retrieved while leaving a cement slurry alongside the borehole wall,
- Figure 2 shows a section of the borehole of Figure 1 while a stinger is pulled there through, and
- Figure 3 shows a section of the borehole of Figure 1 while drilling a lower extension therethrough after hardening of the cement mass.

Referring to Figure 1 there is shown an underground borehole 1 from which a drilling assembly comprising a multibore drill pipe string 2 and a wing type drill bit 3 is retrieved. The drill pipe string 2 contains two co-axial bores 4 and 5, respectively, via which drilling fluid is circulated during the drilling process. The drill bit 3 comprises a central nozzle 6 via which during drilling the drilling fluid is injected from the interior of the inner bore 4 into mud channels 7 alongside the bit face. Openings 8 are provided at the lower end of the outer drill pipe of the string 2 to allow during drilling the drilling fluid carrying drill cuttings to flow up into the outer bore 5 of the string 2.

The drill string 2 is equipped with thick walled drill collars 9 to create weight on bit and a series of stabilizer fins 10 are mounted on the collars 9 for keeping the bit 3 in a centralized position in the

borehole 1.

During the drilling process cement slurry is injected at the top of a pipe-formation annulus 11 between the string 2 and borehole wall to form an annular body 12 of cement slurry that fills at least a lower portion of the annulus 11.

The stabilizer fins 10, in combination with the large diameter drill collars 9, provide a restriction against mixing of the cement slurry 12 with drilling fluid 13 during the drilling process. A further restriction against contact between the drilling fluid 13 and cement slurry 12 during drilling may be provided by a sealing skirt (not shown) around the lower end of the drill collars 9 which opens if the circulation pressure of the drilling fluid exceeds a pre-set value.

The drilling fluid 13 circulating through the bores 4 and 5 during drilling may be any suitable fluid, such as water, oil or a foam. The circulated fluid 13 may have another density than the cement slurry 14 provided that the resulting difference in hydrostatic pressure at the bottom hole is compensated by the circulating pressure of the drilling fluid.

However, at the end of a drilling run it is important that, before the fluid circulation is interrupted and the drilling assembly is retrieved from the borehole as shown in Fig. 1, the bores 4 and 5 are filled with a weighted, preferably bentonitic, liquid that has about the same density as the cement slurry column in the annulus 11. In this way it is ensured that no gravity segregation of the cement slurry will take place after retrieval of the drilling assembly.

The cement slurry contains an over-retarded hydraulic cement, such as Portland cement or an epoxy or polymeric resin, and e.g. chopped reinforcement fibres or additives such as latex polymers and epoxies to optimize the elastic properties of the cement.

The composition of the cement slurry 12 is selected such that the grooves that are pulled through the slurry column during retrieval of the drilling assembly by the stabilizer fins 10 and the wings of the bit 3 flatten out before the cement starts to set.

The cement slurry is over-retarded with a retarding additive which prevents setting of the cement during the drilling process. Before retrieval of the drilling assembly, it is filled with a bentonitic liquid containing a cement solidifying agent which induces the cement to set as soon as the drilling assembly has been retrieved from the borehole.

However, instead of filling the bores 4 and 5 of the drilling assembly with a bentonitic liquid at the end of a drilling run the bores may be filled with an over-retarded cement slurry as well. If in that case the drilling assembly is retrieved from the borehole at least a lower portion of the hole is entirely filled with the over-retarded cement slurry, whereupon a mud core can be spotted in the centre of the borehole by a stinger as illustrated in Figure 2.

As shown in Figure 2 the stinger 20 may be lowered into the borehole 1 after retrieval of the drilling assembly for creating an accurately centralized mud core 13 in the cement slurry 12 and for adding a cement solidifying agent.

Accurate centralization of the stinger 20 may be accomplished by centralizing the lower end of the stinger 20 with a series of bow spring centralizer blades 21. The stinger may be equipped with a mixing sub (not shown) known from Applicants' co-pending patent application No. 8814004 via which the cement solidifying agent is mixed with the cement slurry. Instead of mixing the cement solidifying agent with the cement slurry at a downhole location it may also be mixed with the cement slurry at the surface by circulating the slurry up to the surface where the solidifying agent, and possibly other substances, are added and then circulating the slurry down into the annulus around the stinger whereupon the interior of the stinger is filled with mud and the mud core is spotted in the cement slurry by retrieving the stinger from the borehole as shown in Figure 2.

The cement solidifying agent may consist of calcium chloride ($CaCl_2$) if the cement slurry is over-retarded with a glucose compound. After injecting the calcium chloride into the borehole via the stinger it will neutralize the glucose compound and the cement starts to set.

Alternatively the cement slurry 12 may be over-retarded with a retarder which disintegrates at a critical temperature, in which case the cement solidifying agent may comprise chemicals which cause an exothermic reaction to raise the temperature of the cement slurry 12 above said critical value. Instead of using chemicals also an electric or other heat source may be mounted on the lower end of the stinger to raise the temperature of the slurry 12 to said critical value.

It will be understood that the use of the stinger 20 is optional. The use of the stinger is useful if a drill bit 3 has to be used without a central nozzle.

Figure 3 shows how after setting of the cement slurry to a solid annular lining 30 alongside the borehole wall the borehole 1 may be deepened by a drilling assembly comprising a multibore drill pipe string 32 and a small diameter bit 33. The bit 33 is also used for milling the mud core 13 spotted by the stinger shown in Figure 2 to a desired minimum diameter. During the milling operations the mud core 13 guides the bit 33 such that it is centralized in the hole 1. The drilling assembly of Figure 3 is equipped with a smaller diameter bit 33, stabilizer fins 34 and drill collars 35 than the as-

sembly of Figure 1, whereas the drill string may consist of the same multibore drill string as shown in Figure 1.

During drilling with the assembly of Figure 3 again a drilling fluid is circulated down via an internal bore 36 of the drill pipe string 32 to a central nozzle 37 of the bit 33, from where the fluid is circulated up via openings 38 in the drill pipe string 32 into the outer bore 39 of said string 32 as indicated by the arrows I and II. During drilling the drill string 32 may be rotated as illustrated by arrow III or the string 32 may be kept stationary if the drill bit is driven by a downhole drilling motor (not shown).

During drilling the annular space 40 between the drill string 32 and the inner surface of the cement lining 30 may be completely filled with a fresh cement slurry, but if desired only the annular space 40B between the drill string and the wall 41 of the borehole extension protruding below the cement lining 30 may be filled with cement slurry.

The annular body of the cement slurry may be allowed to set and may be subsequently milled out again to a proper diameter in the same manner as described with reference to Figures 1-3, namely by using an over-retarded hydraulic cement for the slurry and by filling at the end of a drilling run the bores 36 and 39 of the multibore drill string 32 either with a bentonitic liquid having about the same density as the cement slurry or with the cement slurry itself. In the latter case a mud core is spotted by a stinger in the manner described with reference to Figure 2, whereupon the annular body of cement is allowed to set.

It will be understood that instead of drilling the lower extension with the bit that is used for milling out the hardened lining of the upper part of the borehole different bits may be used for the milling and drilling operations as well. In the latter case the bit for drilling the lower extension may be equipped with side reamers which allows to drill the lower extension to the same diameter as the lined upper part of the borehole.

While the foregoing description with reference to the accompanying drawings is directed to preferred embodiments of the method according to the invention, many modifications and variations may be made without departing from the concept of the present invention, as defined in the appended claims.

Accordingly, it should be clearly understood that the method referred to in the foregoing description with reference to the drawing are illustrative only and is not intended as a limitation on the scope of the invention.

Claims

1. A method of drilling and lining a borehole in an earth formation, the method comprising the steps of drilling a borehole section while circulating a first liquid forming a drilling fluid (13) down through a bore (4) of a multibore drill pipe string (2) carrying a drill bit (3) and up through another bore (5) of said drill pipe string (2) while keeping a volume of a second liquid substantially stationary in an annulus (11) between the outer circumference of the drill pipe string (2) and the borehole wall, characterized in that said second liquid forms an over-retarded cement slurry (12) and that the method comprises the further steps of inserting a third liquid having substantially the same density as the cement slurry into at least a lower portion of said bore (4) and said another bore (5), and retrieving the bit (3) and drill pipe string (2) from the borehole while the third liquid flows from said bore (4) and said another bore (5) into the wellbore, whereafter the second liquid solidifies to an annular body of solid cement (30).

2. The method of claim 1 wherein before retrieval of the bit (3) and drill pipe string (2) from the borehole at least a lower portion of the bores (4,5) is filled with the over-retarded cement slurry (12) and after retrieval of the bit (3) and drill pipe (2) from the borehole a stinger (20) is lowered to the bottom of the borehole whereupon the stinger (20) is entirely filled with the third liquid having about the same density as the cement slurry (12) and the stinger (20) is subsequently raised through the borehole while its lower end is centralized in the borehole, thereby spotting a liquid core co-axially inside the annular body of cement slurry (12).

3. The method of claim 1 wherein the third liquid contains a cement solidifying agent, which third liquid is circulated at the end of a drilling run through at least one of the bores (4,5) of the drill pipe string (2) whereupon the bit (3) and drill pipe string (2) are retrieved from the borehole, thereby leaving a core of liquid surrounded by an annular column of cement (12) in the borehole at the end of a drilling run.

4. The method of any preceding claim wherein the third liquid is a weighted bentonitic liquid.

5. The method of any one of claims 1-4 wherein at least part of the volume of the cement slurry (12) is placed in the annulus (11) by injecting a slug of the cement slurry (12) down through at

least one of the bores (4,5) of the drill pipe string (2) and up through the annulus (11).

6. The method of any one of claims 1-4 wherein at least part of the volume of the cement slurry (12) is placed in the annulus (11) by injecting the slurry (12) into the upper end of the annulus (11) and circulating the injected slurry (12) down through the annulus (11) to completely fill at least a lower portion of the annulus (11) with the slurry (12).

7. The method of claims 5 and 6 wherein part of the volume of the cement slurry (12) is placed in the annulus (11) by injecting during an interruption of the drilling process a slug of the slurry (12) down through at least one of the bores (4,5) of the drill pipe string (2) and up through the annulus (11) whereas another part of the slurry (12) is placed by injecting during the drilling process slurry into the upper end of the annulus (11).

8. The method of any preceding claim wherein the injected cement slurry (12) comprises an over-retarded hydraulic cement which only hardens out under influence of a cement solidifying agent.

9. The method of claim 8 wherein the injected cement slurry (12) comprises a hydraulic cement which is over-retarded with a glucose compound and the cement solidifying agent comprises calcium chloride to neutralize the retarder.

10. The method of claim 8 wherein the cement slurry (12) comprises a hydraulic cement which is over-retarded with a retarder which disintegrates at a critical temperature and the cement solidifying agent comprises chemicals which cause an exothermic reaction to raise the temperature above said critical value.

11. The method of any one of claims 5-7 wherein the cement solidifying agent is added to the cement slurry (12) by circulating the slurry (12) up to the surface where the agent is injected into the slurry (12), whereupon the slurry (12) containing the agent is circulated again into the borehole and allowed to set to a solid lining (30) alongside the borehole wall.

Patentansprüche

1. Eine Methode des Bohrens und Auskleidens eines Bohrlochs in einer Erdformation, wobei die Methode einschließt die Schritte des Bohrens eines Bohrlochabschnitts, während eine erste Flüssigkeit (13), die eine Bohrflüssigkeit darstellt, in Abwärtsrichtung durch ein Bohrrohr (4) eines Mehrfachbohrrohrstranges (2), welcher eine Bohrerspitze (3) trägt, und in Aufwärtsrichtung durch ein anderes Bohrrohr (5) des erwähnten Bohrrohrstranges (2) hindurchfließt, umfaßt, wobei ein Volumen einer zweiten Flüssigkeit weitgehend stationär in einem Ringraum (11) zwischen dem äußeren Umfang des Bohrrohrstranges (2) und der Bohrlochwand gehalten wird, dadurch gekennzeichnet, daß die erwähnte zweite Flüssigkeit eine Schlämme eines Zements (12) mit sehr stark verzögerter Abbindefähigkeit darstellt, und daß die Methode die weiteren Schritte des Einführens einer dritten Flüssigkeit, die weitgehend dieselbe Dichte wie die Zementschlämme aufweist, in mindestens einen tieferen Abschnitt des erwähnten Bohrrohres (4) und des erwähnten anderen Bohrrohres (5) in das Bohrloch einschließt, wobei sich danach die zweite Flüssigkeit zu einem ringförmigen Körper (30) von festem Zement verfestigt.

2. Die Methode des Anspruchs 1, wobei vor der Entfernung der Bohrerspitze (3) und des Bohrrohrstranges (2) aus dem Bohrloch mindestens ein unterer Abschnitt der Bohrrohre (4, 5) mit der Schlämme (12) eines Zements mit sehr stark verzögerter Abbindefähigkeit (12) gefüllt wird und nach der Entfernung der Bohrerspitze (3) und des Bohrrohrstranges (2) aus dem Bohrloch ein Hohlstab (20) bis auf den Fuß des Bohrlochs abgesenkt wird, woraufhin der Hohlstab (20) vollständig mit der dritten Flüssigkeit gefüllt wird, welche etwa dieselbe Dichte wie die Zementschlämme (12) aufweist, und der Hohlstab (20) anschließend durch das Bohrloch hindurch angehoben wird, während sein unteres Ende im Bohrloch zentriert wird und dabei einen flüssigen Kern koaxial innerhalb des ringförmigen Körpers aus Zementschlämme (12) einbringt.

3. Die Methode des Anspruchs 1, wobei die dritte Flüssigkeit ein Zementabbindemittel enthält, welch dritte Flüssigkeit am Ende eines Bohrvorganges durch wenigstens eines der Bohrrohre (4, 5) des Bohrrohrstranges (2) hindurchgeleitet wird, woraufhin die Bohrerspitze (3) und der Bohrrohrstrang (2) aus dem Bohrloch entfernt werden, wobei ein Kern aus Flüssigkeit, umgeben von einer ringförmigen Säule aus Zement (12), am Ende des Bohrvorganges im Bohrloch zurückbleibt.

4. Die Methode irgendeines der vorhergehenden Ansprüche, wobei die dritte Flüssigkeit eine beschwerte, bentonithaltige Flüssigkeit ist.

5. Die Methode irgendeines der Ansprüche 1 bis 4, wobei zumindest ein Teil des Volumens der Zementschlämme (12) in den Ringraum (11) durch Einspritzen einer Teilmenge der Zementschlämme (12) in Abwärtsrichtung durch mindestens eines der Bohrrohre (4, 5) des Bohrrohrstranges (2) und in Aufwärtsrichtung durch den Ringraum (11) in diesen eingebracht wird.

6. Die Methode irgendeines der Ansprüche 1 bis 4, wobei mindestens ein Teil des Volumens der Zementschlämme (12) in den Ringraum (11) durch Einspritzen der Schlämme (12) am Kopf des Ringraumes (11) und Zirkulierenlassen der eingespritzten Schlämme (12) in Abwärtsrichtung durch den Ringraum (11), um mindestens einen unteren Abschnitt des Ringraumes (11) vollständig mit der Schlämme (12) zu füllen, eingebracht wird.

7. Die Methode der Ansprüche 5 und 6, wobei ein Teil des Volumens der Zementschlämme (12) in den Ringraum (11) durch Einspritzen einer Anteilsmenge der Schlämme (12) während einer Unterbrechung des Bohrverfahrens in Abwärtsrichtung durch mindestens eines der Bohrrohre (4, 5) des Bohrrohrstranges (2) und in Aufwärtsrichtung durch den Ringraum (11), eingebracht wird, während ein anderer Teil der Schlämme (12) durch Einspritzen der Schlämme während des Bohrverfahrens am Kopfende des Ringraums (11) eingebracht wird.

8. Die Methode irgendeines der vorhergehenden Ansprüche, wobei die eingespritzte Zementschlämme (12) einen hydraulischen Zement mit stark verzögerter Abbindefähigkeit einschließt, welcher nur unter dem Einfluß eines Zementabbindemittels aushärtet.

9. Die Methode von Anspruch 8, wobei die eingespritzte Zementschlämme (12) einen hydraulischen Zement einschließt, dessen Abbindefähigkeit mit einer Glukoseverbindung verzögert worden ist, und das Zementabbindemittel Calciumchlorid einschließt, um den Verzögerer zu neutralisieren.

10. Die Methode von Anspruch 8, wobei die Zementschlämme (12) einen hydraulischen Zement einschließt, dessen Abbindefähigkeit durch einen Verzögerer stark verzögert worden ist, welcher sich bei einer kritischen Temperatur zersetzt, und das Zementabbindemittel Chemikalien einschließt, die eine exotherme Reaktion verursachen, um die Temperatur über den erwähnten, kritischen Wert hinaus anzuheben.

11. Die Methode irgendeines der Ansprüche 5 bis 7, wobei das Zementabbindemittel zu der Zementschlämme (12) durch Zirkulieren der Schlämme bis an die Erdoberfläche hinzugefügt wird, wo das Mittel in die Schlämme (12) eingespritzt wird, woraufhin man die das Mittel enthaltende Schlämme (12) erneut in das Bohrloch zirkulieren läßt und sie längs der Bohrlochwand zu einer festen Auskleidung (30) abbinden läßt.

Revendications

1. Procédé pour forer et chemiser un puits de forage dans une formation terrestre, le procédé comprenant les étapes consistant à forer une section du puits de forage, tout en faisant descendre un premier liquide formant un fluide de forage (13), dans un perçage (4) d'un train de tiges (2) à perçages multiples, portant un trépan (3) et en le faisant remonter dans un autre perçage (5) dudit train de tiges (2) tout en maintenant un volume d'un second liquide sensiblement constant dans un anneau (11) entre la circonférence extérieure du train de tiges (2) et la paroi du puits de forage, caractérisé en ce que ledit second liquide forme une boue de ciment à prise extrêmement retardée (12) et que le procédé comprend les étapes supplémentaires consistant à insérer un troisième liquide possédant sensiblement la même densité que la boue de ciment dans au moins une partie inférieure dudit perçage (4) et dans ledit autre perçage (5), et à retirer le trépan (3) et le train de tiges (2) du puits de forage, tandis que le troisième liquide pénètre depuis ledit perçage (4) et ledit perçage (5) dans le puits de forage, à la suite de quoi le second liquide se solidifie sous la forme d'un corps annulaire de ciment solide (30).

2. Procédé selon la revendication 1, selon lequel avant la récupération du trépan (3) et du train de tiges (2) à partir du puits de forage, on remplit au moins une partie inférieure des perçages (4, 5) avec la boue de ciment à prise extrêmement retardée (12) et, après le retrait du trépan (3) et du train de tiges (2) hors du trou du puits de forage, on descend un tube calibré (20), à la suite de quoi on remplit entièrement le tube calibré (20) avec le troisième liquide possédant approximativement la même densité que la boue de ciment (12), et

ensuite on remonte le tube calibré (20) à travers le puits de forage, tout en centrant son extrémité inférieure dans le puits de forage, ce qui permet de mettre en place un noyau liquide coaxialement à l'intérieur du corps annulaire de la boue de ciment (12).

3. Procédé selon la revendication 1, selon lequel le troisième liquide contient un agent de solidification du ciment, lequel troisième liquide circule à la fin d'un cycle de forage, à l'intérieur d'au moins l'un des perçages (4, 5) du train de tiges (2), à la suite de quoi on retire le trépan (3) et le train de tiges (2) du trou de forage, ce qui laisse subsister un noyau de liquide entouré par une colonne annulaire de ciment (12) dans le puits de forage, a la fin d'un cycle de forage.

4. Procédé selon l'une quelconque des revendications précédentes, selon lequel le troisième liquide est un liquide bentonitique chargé.

5. Procédé selon l'une quelconque des revendications 13-4, selon lequel au moins une partie du volume de la boue de ciment (12) est placée dans l'anneau (11) moyennant l'injection d'un volume de la boue de ciment (12) vers le bas dans au moins l'un des perçages (4,5) du train de tiges (2) et vers le haut dans l'anneau (11).

6. Procédé selon l'une quelconque des revendications 1-4, selon lequel au moins une partie du volume de la boue de ciment (12) est placée dans l'anneau (11) par injection de la boue (12) dans l'extrémité supérieure de l'anneau (11) et circulation descendante de la boue injectée (12) dans l'anneau (11) pour un remplissage complet d'au moins une partie inférieure de l'anneau (11) avec la boue (12).

7. Procédé selon les revendications 5 et 6, selon lequel une partie du volume de la boue de ciment (12) est placée dans l'anneau (11) au moyen de l'injection, pendant une interruption du processus de forage, d'un bouchon de la boue (12) vers le bas dans au moins l'un des perçages (4, 5) du train de tiges (2), et vers le haut dans l'anneau (11), tandis qu'une autre partie de la boue (12) est placée, par injection, pendant le processus de forage, dans l'extrémité supérieure de l'anneau (11).

8. Procédé selon l'une quelconque des revendications précédentes, selon lequel la boue de ciment injectée (12) comprend un ciment hydraulique à prise extrêmement retardée, qui ne durcit que sous l'influence d'un agent de solidification du ciment.

9. Procédé selon la revendication 8, selon lequel la boue de ciment injectée (12) comprend un ciment hydraulique, dont la prise est extrêmement retardée par un composé de glucose, et l'agent de solidification du ciment comprend du chlorure de calcium servant à neutraliser l'agent retardateur.

10. Procédé selon la revendication 8, selon lequel la boue de ciment (12) comprend un ciment hydraulique, dont la prise est extrêmement retardée par un agent de retardement qui se désintègre à une température critique, et l'agent de solidification du ciment comprend des produits chimiques qui provoquent une réaction exothermique qui augmente la température au-delà de ladite valeur critique.

11. Procédé selon l'une quelconque des revendications 5-7, selon lequel on ajoute l'agent de solidification du ciment à la boue de ciment (12) en faisant remonter la boue (12) jusqu'à la ou l'agent est injecté dans la boue (12), à la suite de quoi on fait à nouveau circuler la boue (12) contenant l'agent dans le puits de forage et on la laisse durcir pour former un revêtement solide (30) le long de la paroi du puits de forage.

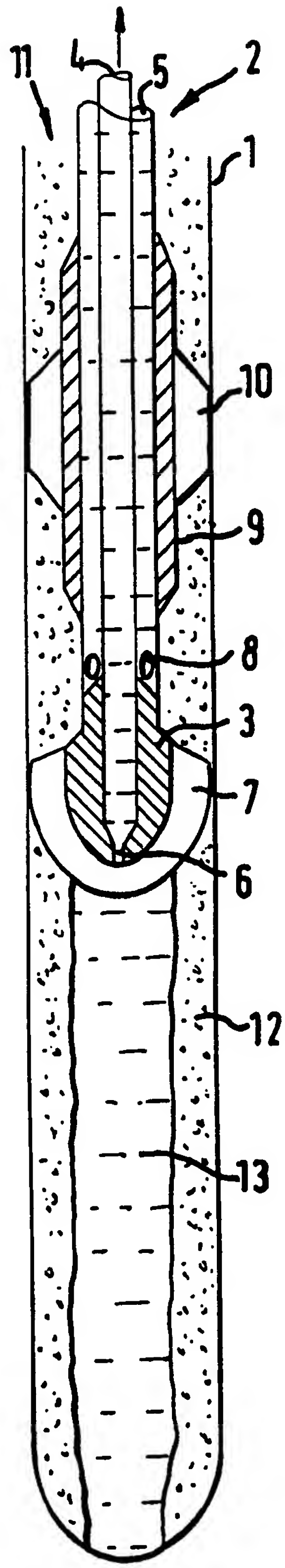

FIG.1

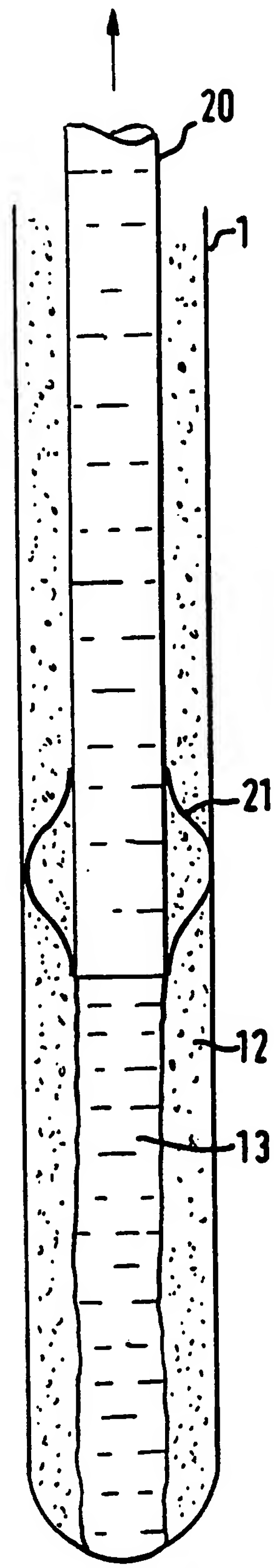

FIG.2

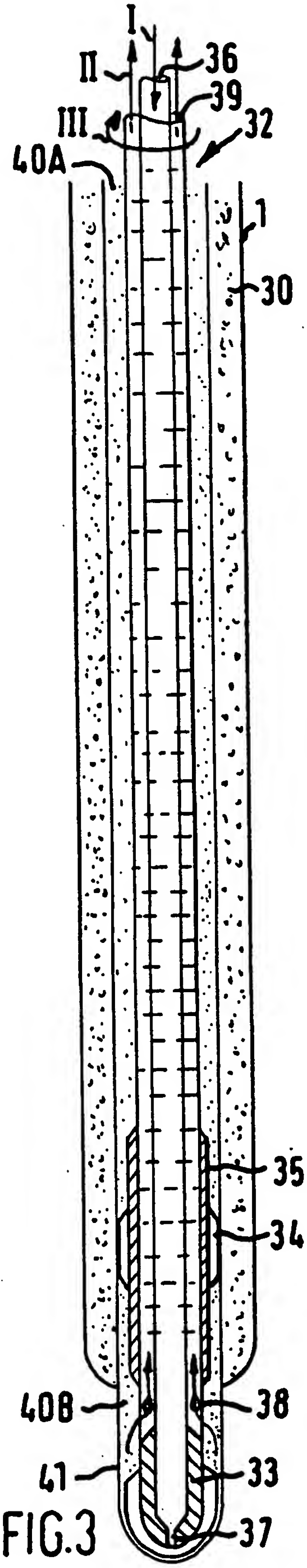

FIG.3